a binding molecule covalently bonded to the gold layer, and

the binding molecule is selected from the group consisting of a nucleic acid, natural or synthetic DNA, natural or synthetic RNA, a peptide, a protein, an antibody, a lipid, a virus, a polymer, a toxin compound, a pharmaceutical compound, a biohazard compound, and an explosive compound.

30. The array of claim 29, wherein the conductive layer comprises aluminum, copper, palladium, platinum, ruthenium, silver, tin, titanium, alloys thereof, oxides thereof, and combinations thereof.

31. The array of claim 29, wherein the gold layer is from about 1 nm to about 10 nm in thickness.

32. The array of claim 29, wherein the binding molecule is covalently bonded to the gold layer by a gold-thiol covalent bond.

33. The array of claim 29, further comprising a row decoder, a column decoder, a preamplifier, and at least one current source.

34. The array of claim 29, further comprising microfluidic circuits.

35. The array of claim 29, comprising a plurality of detection sites.

36. The array of claim 29, having a magnetoresistance (MR) ratio, $\Delta R/R_o$, from about 10% to about 50%.

37. An antiferromagnetically coupled magnetic nanoparticle comprising two or more ferromagnetic layers and a covalently bonded target molecule, wherein:

the ferromagnetic layers comprise Fe_xCo_{1-x} (x is about 0.5 to about 0.7), Co, Co alloys, ferrite, Cobalt nitride, Cobalt oxide, Co—Pd, Co—Pt, Iron, Iron alloys, Fe—Au, Fe—Cr, Fe—N, Fe_3O_4, Fe—Pd, Fe—Pt, Fe—Zr—Nb—B, Mn—N, Nd—Fe—B, Nd—Fe—B—Nb—Cu, Ni, Ni alloys, or mixtures thereof; and

the target molecule is a nucleic acid, DNA, RNA, a peptide, a protein, an antibody, a lipid, a virus, a polymer, a toxin compound, a drug compound, a biohazard compound, or an explosive compound.

38. The nanoparticle of claim 37, wherein the ferromagnetic layers are separated by at least one nonmagnetic spacer layer.

39. The nanoparticle of claim 38, wherein the spacer layer comprises ruthenium, a ruthenium alloy, chromium, a chromium alloy, gold, a gold alloy, a noble metal, a noble metal alloy, or mixtures thereof.

40. The nanoparticle of claim 37, wherein the nanoparticle further comprises at least one paramagnetic layer.

41. The nanoparticle of claim 37, wherein the nanoparticle further comprises at least one superparamagnetic layer.

42. The nanoparticle of claim 37, wherein the nanoparticle is nonmagnetic in the absence of a magnetic field and is magnetic in the presence of a magnetic field.

43. The nanoparticle of claim 37, further comprising a gold surface layer or a glass surface layer.

44. The nanoparticle of claim 37, characterized as having a mean diameter of about 20 nm to about 250 nm.

45. The nanoparticle of claim 37, characterized as having a mean diameter of about 20 nm to about 50 nm.

46. A method of preparing an antiferromagnetically coupled magnetic nanoparticle conjugate, the method comprising:

providing an antiferromagnetically coupled magnetic nanoparticle comprising a gold surface layer or a glass surface layer;

providing a target molecule selected from the group consisting of a nucleic acid, DNA, RNA, a peptide, a protein, an antibody, a lipid, a virus, a polymer, a toxin compound, a pharmaceutical compound, a biohazard compound, and an explosive compound; and

contacting the nanoparticle and the target molecule under conditions suitable for the formation of a covalently bonded nanoparticle-target molecule conjugate.

47. The method of claim 46, wherein the conjugate is covalently bonded by a sulfur-gold covalent bond.

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